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DEHYDROGERANIIN, FUROSININ AND FUROSIN, DEHYDROELLAGITANNINS FROM *GERANIUM THUNBERGII*

Takuo Okuda,* Tsutomu Hatano and Kazufumi Yazaki
Faculty of Pharmaceutical Sciences, Okayama University,
Tsushima, Okayama 700, Japan

Three new dehydroellagitannins, dehydrogeraniin (**2**), furosinin (**9**) and furosin (**10**), have been isolated from *Geranium thunbergii*, and their structures elucidated.

KEYWORDS —— *Geranium thunbergii*; Geraniaceae; tannin; hydrolyzable tannin; dehydroellagitannin; dehydrogeraniin; furosinin; furosin; ^{1}H- and ^{13}C-NMR spectra

Three new dehydroellagitannins have been obtained from the dried plant of *Geranium thunbergii* SIEB. et ZUCC. (Japanese name, Gen-no-shoko) (Geraniaceae). Following deposition of geraniin (**1**)[1-3] from the ethyl acetate extract,[1] these tannins were isolated from the mother liquor by droplet counter-current chromatography and the column chromatography on Sephadex LH-20.

Dehydrogeraniin (**2**) forms yellow amorphous powder, $C_{41}H_{28}O_{28}\cdot 6H_2O$, $[\alpha]_D$ -137° (c = 0.5, MeOH), UV λ_{max}^{MeOH} nm (log ε) 224 (4.97), 283 (4.56). The presence of two dehydrohexahydroxydiphenoyl (DHHDP) groups[3] in addition to a galloyl group [δ 7.24 (s) and 7.23 (s), 2H in total] and a monosaccharide core (δ 6.42, 6.37 and 5.83 - 4.35) in the molecule is shown by the ^{1}H-NMR[4] (200 MHz) peaks of methine [δ 4.92 (d, J=1.5 Hz, 2/5H), 5.33 (s, 3/5H); 5.28 (s, 2/5H), 5.30 (s, 3/5H)], vinyl [δ 6.29 (d, J=1.5 Hz, 2/5H), 6.60 (s, 3/5H); 6.72 (s, 2/5H), 6.74 (s, 3/5H)] and of the aromatic (δ 7.24 - 7.28, 2H) protons. These proton peaks indicate that the equilibration between the six- and five-membered hemiacetal structures[3] occurred mainly for one of the two DHHDP groups in the ratio of 3 to 2. However, other small peaks in the spectrum indicate that the other DHHDP group also to a small extent forms an equilibriun mixture of the two structures.

Dehydrogeraniin was condensed with two moles of *o*-phenylenediamine to give a product (**3**), $C_{53}H_{31}N_4O_{22}\cdot 6H_2O$. The presence of only one methine proton (δ 5.42, d, J=1.5 Hz) in the ^{1}H-NMR spectrum of **3** shows that one of the two heterocyclic groups has already been aromatized. In an acidic solution, this product was slowly converted into another product (**4**), $C_{53}H_{31}N_4O_{22}\cdot 6H_2O$, which in the ^{1}H-NMR spectrum showed aromatization in the second phenazine moiety. The upfield shift of H-1 of glucose upon the production of **4** from **3** is analogous to the ^{1}H-NMR spectral changes observed upon the aromatization in "phenazine B" (**8**) from **1**.[2,3] Therefore one of the

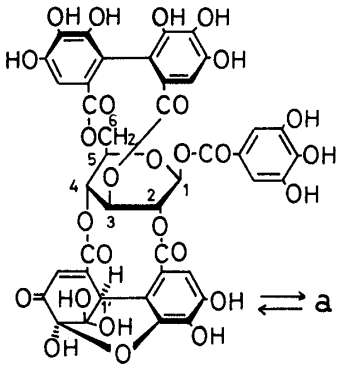
two DHHDP groups in dehydrogeraniin, which aromatized later than the other one, should be located at O-2 and O-4 with the same orientation as the DHHDP group in **1**.

Product **4** was methylated with diazomethane, and then methanolyzed to give methyl tri-*O*-methylgallate and (+)-methyl 4-methoxy-3-(4,5,6-trimethoxy-2-methoxycarbonylphenyl)phenazine-2-carboxylate (**5**),[2] which were identified with authentic specimens,[3b] and glucose which was identified by gas chromatography of the trimethylsilyl derivative. One of the two phenylphenazine groups in **4** was removed by prolonged treatment with boiling water to give a product (**6**), $C_{33}H_{24}N_2O_{16}\cdot 2.5H_2O$, which in the ^{1}H-NMR spectrum showed upfield shifts of H-2 (δ 5.88 → 4.30) and H-4 (δ 5.83 → 4.40) from those of **4**. The galloyl group in **6** was selectively removed by the treatment with tannase, to yield a product (**7**), whose ^{1}H-NMR spectrum shows retention of the phenylphenazine group [δ 7.01 (s, 1H), 7.95 (s, 1H), 7.95 - 8.40 (m, 4H)]. Analogy of H-2 ~ H-6 pattern of glucose to that of 3,6-hexahydroxydiphenoyl (HHDP)glucose,[5,6] and a large upfield shift (> 0.7 ppm) of H-1 of glucose are also shown. The galloyl group in dehydrogeraniin therefore should be at O-1 of glucose.

The orientation of the DHHDP group at O-3 and O-6 of glucose is indicated in formula **2** by the downfield shift of H-4 of **4** (δ 5.83) from H-4 in **8** (δ 5.48).[2,3] This is based on the identity of the pyranose-ring conformation between **4** and **8** exhibited by the ^{1}H-NMR spectra. This assignment was supported by a comparison of **4** and **8** for the shifts of H-3 [δ 5.44 (**4**), 5.48 (**8**)] and H-6, 6' [δ 4.17, 4.96 (**4**); 4.03, 4.72 (**8**)].

Furosinin (**9**) was obtained as a yellow amorphous powder, $C_{34}H_{24}O_{24}\cdot 3H_2O$, $[\alpha]_D$ -58° (c = 0.5, acetone - water, 9:1), UV λ_{max}^{MeOH} nm (log ε) 224 (4.76), 277 (4.25). The ^{1}H- and ^{13}C-NMR spectra of **9** showed the presence of two DHHDP groups and a sugar core, and an absence of a galloyl group. These spectra are more complicated than those of **2**, presumably due to the anomerization induced by the lack of galloyl group which was present at O-1 of glucose in **2**。 This presumption was substantiated by the production of **9** upon the treatment of **2** with tannase. The H-1 peak in the ^{1}H-NMR spectrum of **2** (δ 6.37, 6.42) shifted upfield (> 0.7 ppm) upon the production of **9**, and the presence of α- and β-anomers of **9** was exhibited by the ^{13}C-NMR spectrum [δ 88.9 (α); δ 96.3, 97.0 (β)]. These results established the structure of furosinin as **9**.

Furosin (**10**) forms yellow crystals, $C_{27}H_{22}O_{19}\cdot 4H_2O$, $[\alpha]_D$ -146° (c = 0.5, acetone), UV λ_{max}^{MeOH} nm (log ε) 223 (4.80), 283 (4.43). Mutarotation, $[\alpha]_D$ -154° → -146° (c = 0.5, acetone - water, 9:1), was observed in the same direction as that of geraniin.[3] The ^{1}H-NMR spectrum shows peaks assignble to a galloyl group, DHHDP group, and a glucose core, at δ 7.26, 7.30, 6.55, 5.37, 6.47 and 5.5 - 3.9. The DHHDP group of crystalline furosin forms the hydrated six-membered hemiacetal structure, as indicated by the comparison of its ^{1}H-NMR peaks to those of crystalline geraniin.[3] Occurrence of the five-membered hemiacetal structure upon the mutarotation was shown by the peaks



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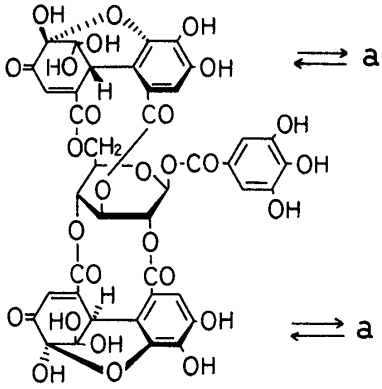

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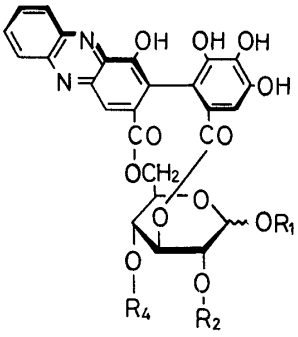
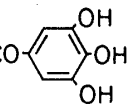
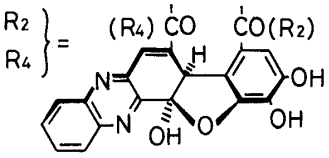
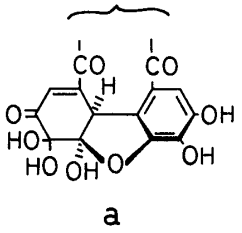


3 : R_1 = (β)-CO 





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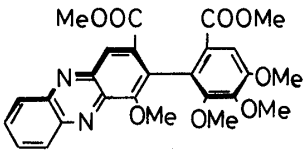

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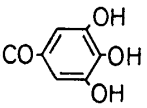
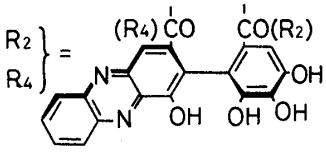
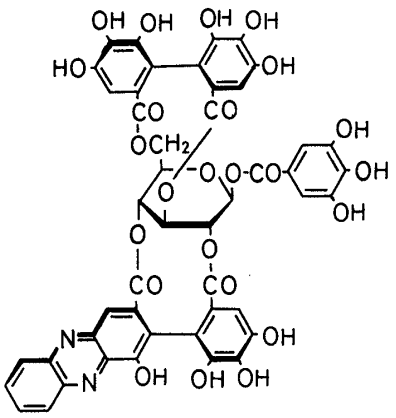
4 : R_1 = (β)-CO 





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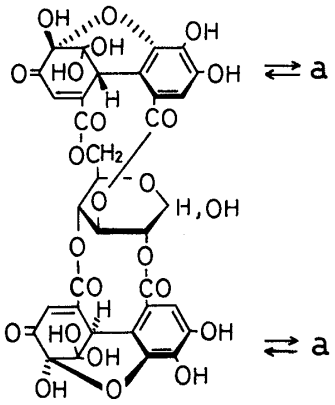

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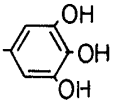
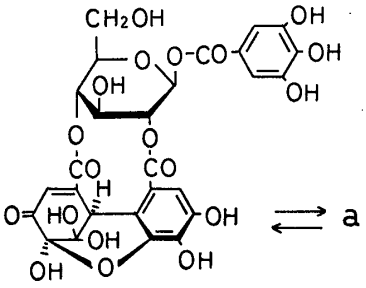
6 : R_1 = (β)-CO 

R_2 = R_4 = H

7 : R_1 = R_2 = R_4 = H



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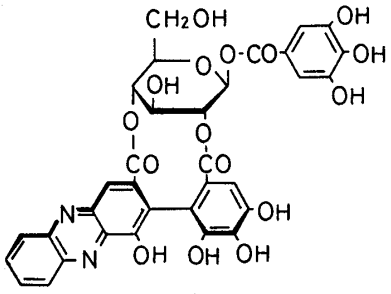

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at δ 4.98 (d, J=1.5 Hz, methine) and δ 6.28 (d, J=1.5 Hz, vinyl) in the ^{1}H-NMR spectrum measured in D_2O-containing acetone-d_6.

Upon the condensation with *o*-phenylenediamine, furosin gave a product (**11**), $C_{33}H_{24}N_2O_{16}\cdot 3H_2O$, whose ^{1}H-NMR spectrum showed upfield shift of H-1 (δ 6.15; H-1 of **10**, δ 6.47) in a way analogous to the production of **8** from geraniin.[2,3] This supports the location and orientation of the 1'*R*-DHHDP group in **10** at O-2 and O-4 the same as in **1**. Among the sugar protons of **10**, those assignable to H-3 (δ 4.46) and H-6 (δ 3.95) shift about 0.8 - 1.0 ppm higher than those of **8** (δ 5.48 and 4.72). Therefore the structure of furosin is assumed to be **10**, an analog of **1**, in which the HHDP group at O-3 and O-6 is lacking.

Among these three new tannins, **10** is presumed to have been produced when the plant was dried as it was isolable only from dried plants.

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4) ^{1}H-NMR spectra were measured with a Hitachi R22-FTS instrument (90 MHz) in acetone-d_6 or acetone-d_6 - D_2O, unless otherwise mentioned.

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6) The ^{1}H-NMR spectrum of this compound prepared from corilagin will be published later.

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